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ELECTROMAGNETIC RADIATION SYSTEM (EMRS) FOR SUSCEPTIBILITY TEST--ETC(U)

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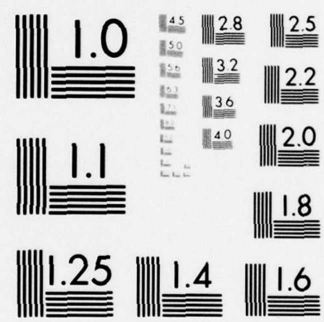
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The function of the Electromagnetic Radiation System (EMRS) is to generate electromagnetic energy so as to produce a constant field strength that can be automatically scanned as a function of frequency. The design objective is to cover the frequency range of 30 Hertz to 40 Gigohertz with field strength intensities up to 200 Volts per meter. A stripline approach is described and proposed for use as the field generating device for the lower frequencies. The use of defocused parabolas are proposed for use at the higher frequencies. The final system configuration bandpass filters, automatic power leveling subsystem and design trade-offs are described.

TABLE OF CONTENTS

I. INTRODUCTION.

This report describes the activities and developments concerning Phase II of Electromagnetic Radiation System (EMRS) Program during the period 1 Jan. 1978 to 31 March 1978. The purpose of Phase II of EMRS program is to develop the hardware to demonstrate the feasibility of the theoretical design considered in Phase I.

II. STATUS OF EMRS EQUIPMENT.

A. During the period of this report, the following equipment has been received:

1. Sweep Oscillator system including:

a. HP8620C mainframe

b. HP86222B 10 MHz to 2.4 GHz RF plug-in.

c. HP86260A 12.4 GHz to 18 GHz RF plug-in.

2. RF Amplifiers.

Logimetrics Model A600S for 1 to 2.1 GHz.

3. RF power control and leveling subsystem components.

All power control and leveling circuit components have been received except for one HP8495H programmable attenuator. Delivery is expected in early April.

4. Pulse modulation subsystem components.

All components for the RF pulse modulation subsystem have been received.

5. Equipment rack.

The equipment rack for mounting of EMRS rack-mountable components has been received and assembled.

6. Interconnecting cables, connector and transition pieces have been received.

B. Remaining Equipment To Be Received.

1. Sweep Oscillator components.

The HP86235A RF plug-in for 1.7 to 4.3 GHz should be received during the week of 10 April 1978.

2. RF Power Amplifiers.

The Logimetric A600L (1 to 2.1 GHz) and A200U (12.4 to 18 GHz)

amplifiers should be received during the week of 3 April 1978.

3. Tunable bandpass filters:

a. The tunable bandpass filters for the bands 30 to 60 MHz, 1 to 2.1 GHz, and 2.1 to 4 GHz have been completely specified and ordered. Delivery is expected in August 1978.

b. The tunable bandpass filter for the 12.4 to 18 GHz band has been completely specified. Ordering of the filter is anticipated during the next reporting period.

III. DESIGN CONSIDERATIONS.

A. Tunable Bandpass Filters Design.

The design specifications for the tunable bandpass filter were originally based on the assumption that the filter tuning mechanism would be driven by the sweep output of the sweep oscillator. This required a very close correlation between the sweep output voltage and the corresponding sweep oscillator frequency.

Unwanted variations in the frequency of the sweep oscillator around the center frequency f_o would require that the filter bandwidth be wide enough to account for these variations. However, to obtain sufficiently wide bandwidth using cavity tuned filters would require unacceptable compromises in other important design parameters. Greater cost would also be necessary to develop the wider pass band required.

Because of the above considerations, it was decided that a more conventional narrow bandwidth filter would be used. The filter drive would not be derived from the sweep oscillator sweep output voltage. Instead, the signal needed to position the filter pass band at the oscillator frequency f_o would be derived from the RF signal directly.

For the 30 to 60 MHz band, a frequency counter will be used to count the RF frequency directly and convert the count to a parallel binary word which will directly drive the filter positioning unit.

For the remaining bands, 1 to 2.1 GHz, 2.1 to 4 GHz, and 12.4 to 18 GHz, the signal to position the filter will be derived using a dual slope filter technique. The filter will consist of four basic components; the main bandpass filter tuned to f_o, two auxiliary bandpass filters tuned to $f_o + \Delta f$ and $f_o - \Delta f$, the filter positioning unit. Referring to figure 1 and figure 2, the filter would operate in the following manner:

The main and auxiliary filter would be tuned simultaneously across the frequency band of interest such that the relationship between the three passbands would remain as shown in Figure 1. As can be seen from the figure, the skirts of the auxiliary filters cross at a frequency equal to main filter center frequency f_o.

Assume, for example, that the filters are tuned to a frequency f_o. As along as the frequency of the sweep oscillator is at f_o = crossover point, then the detected outputs of the auxiliary filters are equal. This causes the output of the differential detector to be zero. Now if the RF frequency drops below f_o, the detected output of the $f_o - \Delta f$ filter decreases. The resulting difference in the two detected outputs is amplified and applied to the filter positioning units and repositions the filter passband to the new RF frequency. The unit would respond similarly if the RF frequency increases above f_o. In this way the crossover point of the auxiliary filters is always positioned at the RF frequency of the sweeper which, in turn, centers the main filter at the same frequency.

B. Automatic Power Leveling Subsystem.

The basic concept for the automatic power leveling subsystem was discussed in the EMRS fourth(1) and fifth(2) quarterly reports. Since then, design changes have been made to account for limitations in the response of the crystal detectors available and also to allow for future computer control of RF power level if desired.

Figure 3 shows a block diagram of the present power leveling system including the computer interface and an additional programmable RF attenuator in front of the crystal detector.

1. ECOM-76-0332-4, Electromagnetic Radiation System (EMRS) for Susceptibility Testing, April 1978.
2. ECOM-76-0332-5, Electromagnetic Radiation System (EMRS) for Susceptibility Testing, July 1978.

Local (manual) or remote (computer) control of RF power is selected by a control panel toggle switch. In the local mode, programming of th 0 to 81 db RF attenuator and the crystal attenuator is done using various combinations of seven front panel toggle switches. In the remote mode, the front panel toggle switches are disabled and control of the attenuator is provided by IEEE 488 Bus information latched into the CDP1852 Bus latch.

Attenuator A1 varies the RF power out over a 70 db range in 10 db steps. A2 varies the power over an 11 db range in one db steps. The attenuation of A1 and A3 are varied in a complementary way so that a 10 db increase in A1 attenuation is coincident with a 10 db decrease in A2. This keeps the RF input to the detector constant and approximately in the center of its dynamic range.

The 1 db changes in RF power are compensated for by automatic changes in the offset and gain of the leveling loop amplifier. The gain and offset of the leveling loop amplifier are controlled digitially by the four inputs from the control bus.

C. Design Trade-off's.

The basic design goals of the EMRS prototype hardware were outlined in the fifth quarterly report(2) and in the Design Plan. The more important design goals were to:

1. Demonstrate the feasibility of generating a 200 volts per meter field strength using a stripline or refocused parabola antenna configuration.

2. Demonstrate that the field strength can be programmed either manually or automatically over a range from 200 volts per meter to 0.001 volts per meter.

3. Obtain a signal purity such that harmonics and spurious emissions would be greater than 100 db below the carrier frequency.

4. Provide items 1 through 3 above in the frequency bands 30 to 60 MHz, 1.0 - 2.0 GHz, 2.0 to 4.0 GHz and 12.4 to 18 GHz. It is anticipated that the EMRS demonstration hardware will meet all of the above design goals with the following exceptions.

a. Field Intensity. A 200 V/M field intensity will be obtained at all frequencies in the 30 to 60 MHz and 1 to 2 GHz bands using the stripline configuration.

In the 2 to 4 GHz band using a refocused parabola, a 200 volts/meter field intensity will be obtained except for frequencies below approximately 2.3 GHz. This result assumes that the amplifier saturated power output is >224 watts RMS and cable and filter losses are <1.82 db. The lower frequency limit for a 200 V/M field could be reduced by increasing the output power of the amplifier and using a special larger cavity filter. This would result in increased system cost for both the amplifier and filter. Reducing cable loss would also reduce the lower limit on frequency. However, this would require shorter cable lengths with decreased flexibility for positioning of the antenna in the screen room. Filter insertion loss could be reduced but this would require additional cost also. Reducing filter loss would be traded for wider bandwidth which, in turn, introduces passband distortion when tuning over octave bandwidths.

b. Programming of field intensity. Programming of field intensity will be accomplished by externally attenuating the RF output signal from the sweep oscillator. The sweep oscillator output will be maintained relatively constant and will drive a programmable attenuator which can be either manually or computer controlled. The range over which the sweep oscillator signal will be externally attenuated is 81 db in 1 db steps. To achieve smaller steps in attenuation would require developing a special attenuator with say 1 db total attenuation in 0.1 db steps. An alternate method would be

to continuously vary the attenuation over a 1 db range using an in-line vari-losser (pin diode). This would require design of the pin diode driver circuit and computer interface circuits.

Since a 1 db change in attenuation corresponds to approximately a 20% change in signal level, this is considered an acceptable increment for demonstrating programmable field intensity.

c. Signal purity. To obtain a signal purity such that harmonics and spurious signals would be attenuated to 100 db below the fundamental, tunable bandpass filters are required. The filters are required to track the sweep oscillator RF frequency. Since the sweep oscillator chosen for the demonstration EMRS is basically a voltaged controlled YIG device, it has an inherent frequency error of greater than $\pm 1\%$. To track an RF frequency $f_o \pm 1\% f_o$ would require a tunable bandpass filter with a bandwidth of at least $\pm 1\%$. In addition to this fundamental $\pm 1\%$ error, other errors such as tuning voltage non-linearity also decrease the overall correlation of RF frequency and sweep voltage. These errors increase the required bandwidth of the filter.

However, when the filter bandwidth is wider to account for sweep oscillator frequency errors, the shape of the passband becomes distorted and waveguide modes are allowed to pass through this filter. In addition, the wider bandwidth increases in band noise.

Because of these considerations, it is necessary to restrict the filter 0.5 db bandwidth to less than approximately $\pm 0.3\%$. Such a bandwidth is too narrow to remain centered on an RF frequency which is varying by at least $\pm 1\%$.

Improvement in the accuracy of the RF signal source to $< \pm 1\%$ would require going to a frequency synthesizer with a concomitant factor of two

or three increase in cost.

A more cost effect approach would be to not use the oscillator sweep output voltage to control the filter tuning, but instead, to develop the control voltage by directly sensing the RF frequency. Such a scheme is described in section III A. No compromise of the -100 db signal purity requirement should be required with the tunable filter control in this way.

4. Frequency bands. The frequency bands to be covered in the demonstration EMRS hardware phase were specified as 30 to 60 MHz, 1.0 to 2.0 GHz, 2.0 to 4.0 GHz, and 12.4 to 18 GHz. These bands will be covered except for one change. The frequency range between 1.0 GHz to 4.0 GHz will be covered in two bands with the lower band from 1.0 to 2.10 GHz and the upper band from 2.10 GHz to 4.0 GHz. The bands were divided in this way because of standing wave ratio limitations on the power amplifier outputs.

The Logimetrics power amplifiers in the 1 to 2 GHz and 2-4 GHz bands were purchased with an option which automatically shuts down the Traveling Wave Tube amplifier when the VSWR seen by the amplifier output exceeds approximately 2.7:1. The tube is also designed to shut down when the total power reflected back into the amplifier exceeds 50 watts. These shut down conditions can occur when operating the 2 to 4 GHz amplifier (A600S) at 2 GHz and 200 watts with a 2nd harmonic at -6 db down or 50 watts. The amplifier works into a reflective filter and therefore the 50 watts of 2nd harmonic power is reflected back into the amplifier, shutting it down. A method to reduce the reflected 2nd harmonic power, is to restrict the band to 2.1 to 4.0 GHz. The 2nd harmonic of 2.1 GHz is 4.2 GHz. 4.2 GHz is outside the passband of the TWT and is, therefore, at a level below the 50 watts needed to shut the tube down.

To cover the 2.0 to 2.1 GHz frequency band, the 1.0 to 2.0

GHz band is extended to 2.1 GHz. The RF power requirement in this band is 100 watts. However, to reduce distortion, a 200 watt amplifier (A600L) will be used and operated at 100 watts. The effect of this is to reduce distortion by operating the amplifier in its more linear range. The 2nd harmonic will be -10 db down or 10 watts. This power level can be safely reflected back into the amplifier without causing shutdown.

IV. FUTURE PLANS.

During the next report period, the following developments are anticipated:

1. Fabrication, assembly and testing of all control circuitry and hardware.

2. Receipt of all remaining purchased equipment except for the tunable bandpass filters.

3. Mounting of all equipment in the equipment rack.

4. Fabrication of all cable assemblies.

5. Fabrication of antenna mounting hardware.

6. Ordering of 12.4 to 18 GHz tunable bandpass filter.

7. Final assembly and preliminary testing of EMRS Demonstration hardware.

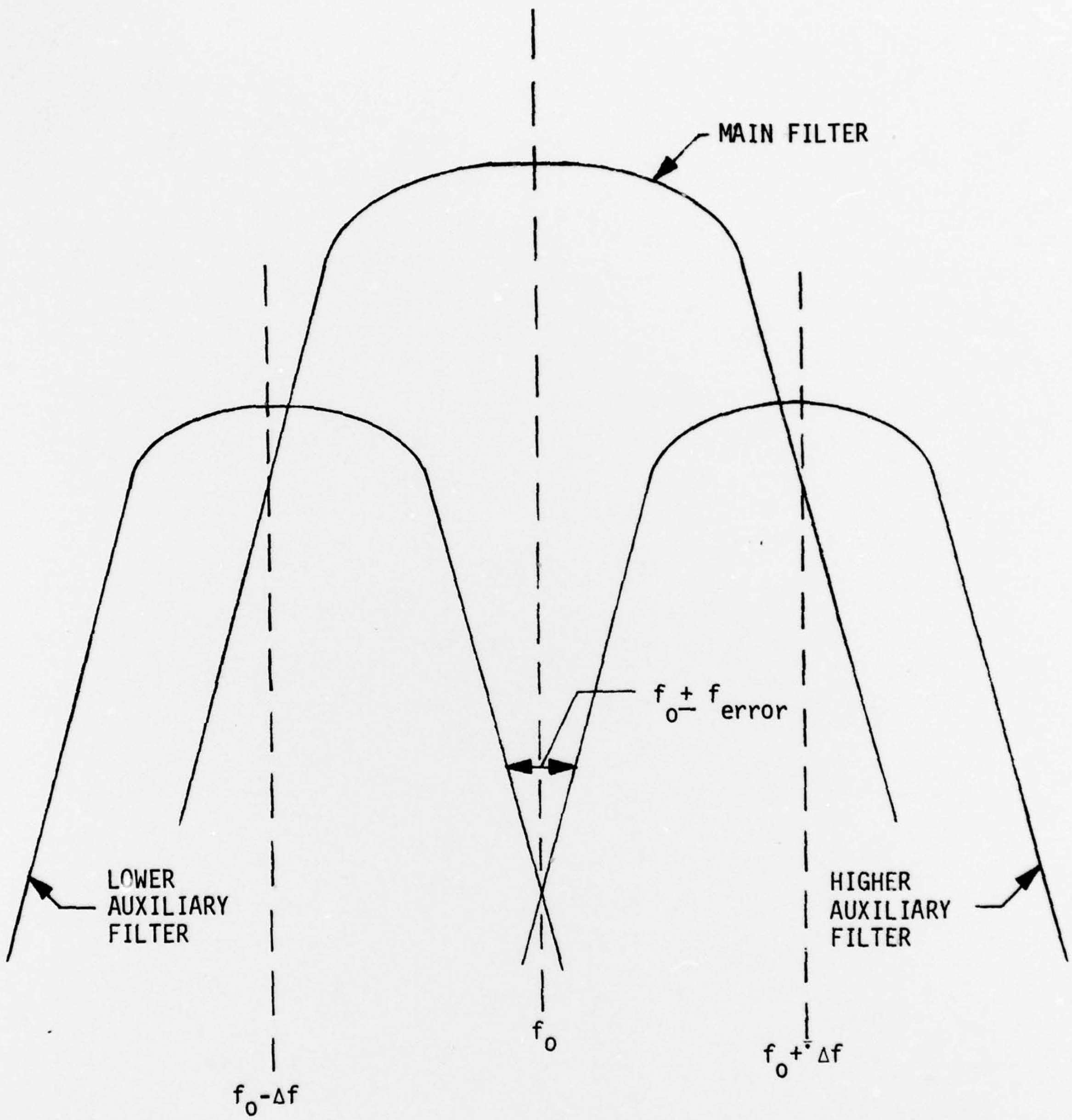

Figure 1. Relative positions of the main and auxiliary filter passbands.

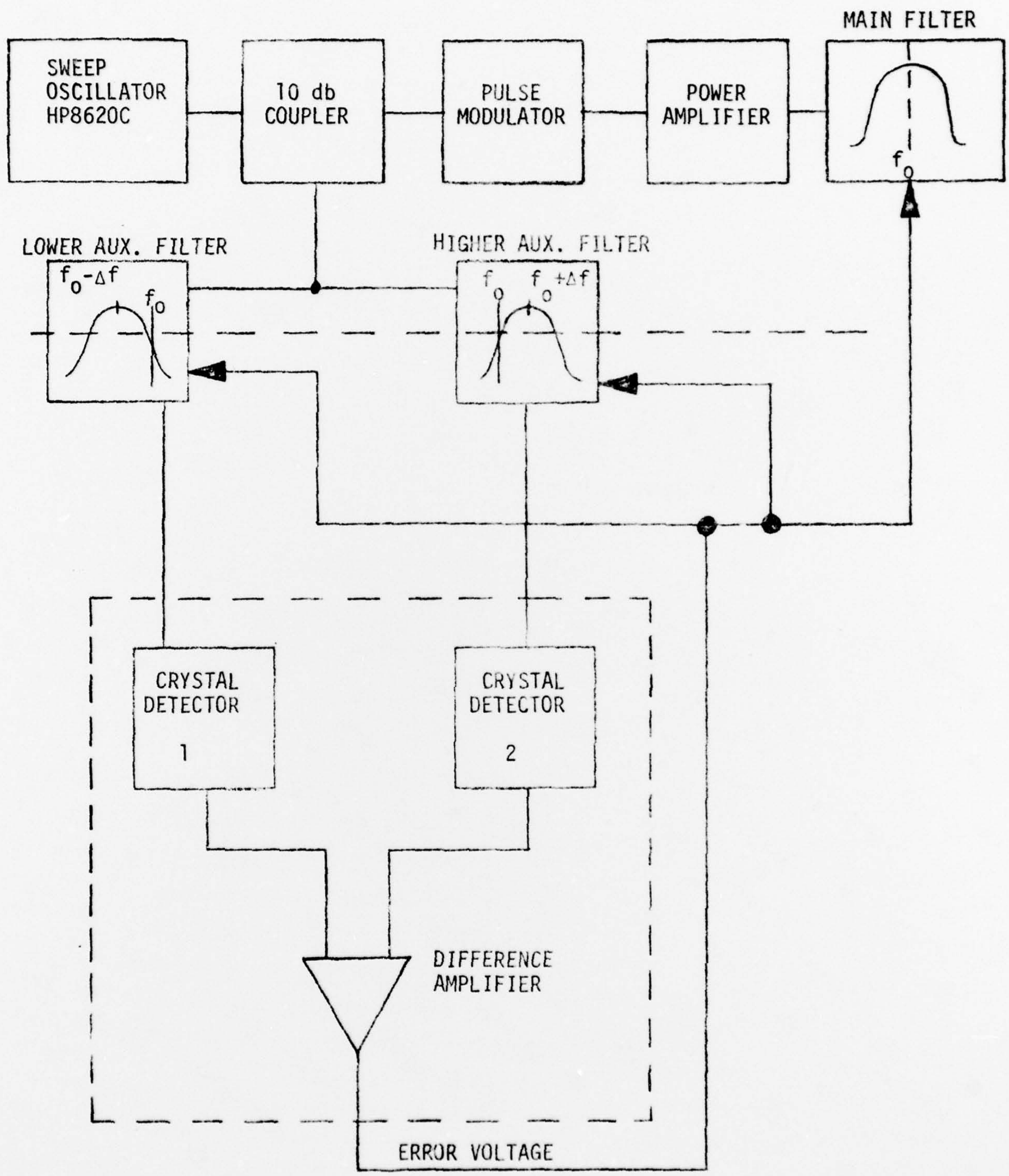

Figure 2. Filter positioning system for the 1 to 2.1 GHz, 2.1 to 4 GHz, and 12.4 to 18 GHz filters.

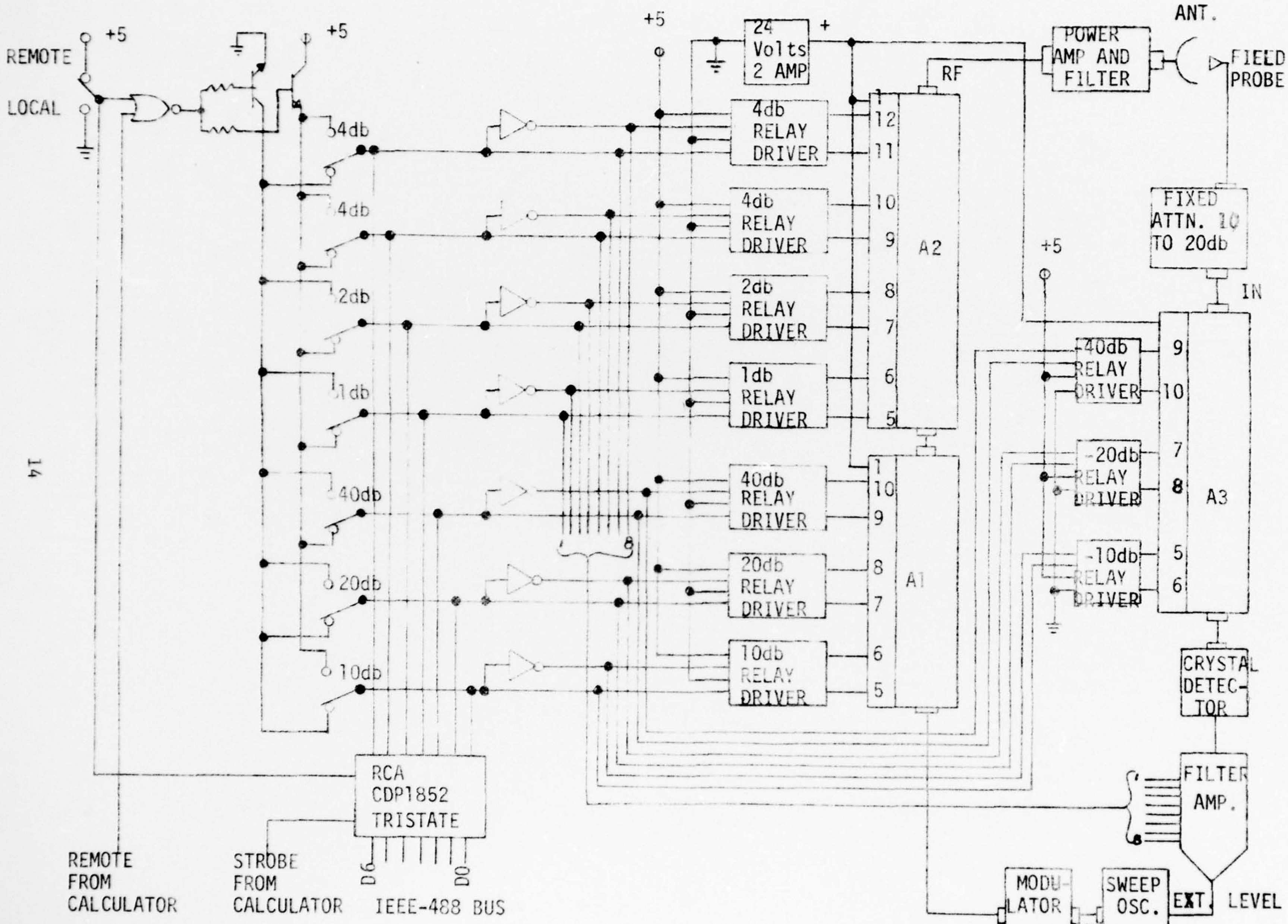

Figure 3. Programmable attenuation and automatic leveling circuit.

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